NOTE ON VOLCANIC EXPLOSION EARTHQUAKES OF THE VOLCANO SAKURAJIMA

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BY

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1. Observation

Near the Sakurajima Volcanological Observatory, a tripartite observing system was set up and the map of tripartite site is shown in Fig. 1. The seismometers used are three vertical components of SH-II type, two horizontal components of SH-II, and four horizontal components of portable type. The arrangement of these seismometers is listed in Table 1 with their principal constants. The outputs of seismometers are connencted with galvanometers of frequency 30 cycles through transistor amplifiers. The volcanic explosion earthquakes were observed only in night from 3rd to 6th in August, 1962.

2. Orbital motions and propagation velocities of early arrived phases

An example of seismograms obtained is shown in Fig. 2, in which only the

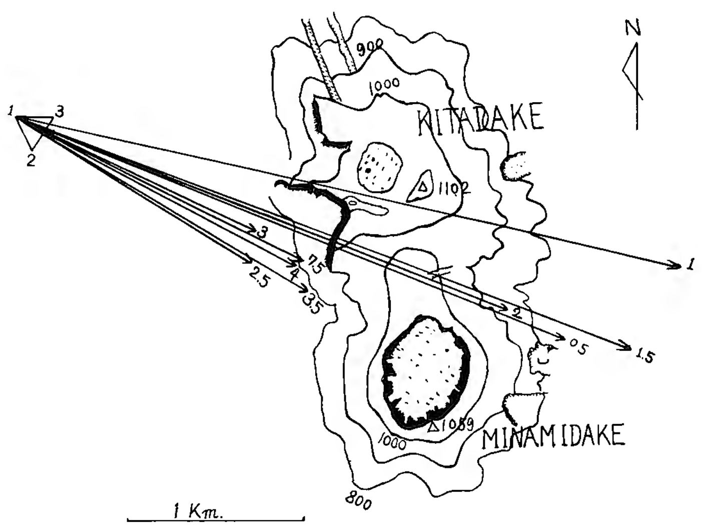

Fig. 1 Map of tripartite observing site and the propagation velocities of some phases.

Table 1 Arrangement of seismometers and their principal constants.

component	T_1 (sec.)	T_2 (c.p.s.)	h_1	h_2	arrangement
horizontal (SH-2)	0.7	30	1.0	1.0	2-comps. (longitude and tangential to the crater) at 1-position.
horizontal (portable)	0.7	30	1.0	1.0	2-comps. (longitude and tangential to the crater) at 2- and 3-position.
vertical (SH-2)	0.7	30	1.0	1.0	1-comp. at each position.

T_1: period of pendulum, T_2: period of galvanometer, h_1: damping constant of pendulum, h_2: damping constant of galvanometer

three components of the position 1 are drawn. The other seismograms are also very similar to the example. For brevity, the suitable positions, as the wedge or traff, on the traces are numbered as shown in Fig. 2. The phase veolocities of the phases 0.5, 1.0, 1.5 and 2.0 are determined from the vertical components of three positions, and those of the phases 2.5 3.0, 3.5, 4.0 and 7.5 are determined from the longitudinal components. These results are listed in Table 2 and shown in Fig. 1. On the other hand, the orbital motions of the wave protions, 0.5～2.0, 2.0～5.0 and 5.0～8.0 are shown in Fig. 3. It is not so difficult that we recognize the existences of the particular three or four wave groups, each of which is different in wave properties from the others. The first wave group corresponding to the phases 0.5～2.0 is predominant in the vertical component and appears to be propagated from anywhere northwards in comparison with the later phases, of which the propagation directions point towards the northern edge of the Minamidake crater. The second wave group corresponding to the phases 2～3 is polarized in the ground surface of observing position, and predominant in the component along the propagation direction. The third wave group corresponding to the phases

Table 2 List of phase velocities of some phases. It must be noted that they are not so accurate.

phase No.	apparent velocity km/sec.	direction
0.5	1.58	S 67.0° E
1.0	1.82	S 76.5° E
1.5	1.76	S 68.5 E
2.0	1.42	S 67.5° E
2.5	0.75	S 58.0° E
3.0	0.72	S 64.0° E
3.5	0.90	S 58.5° E
4.0	0.86	S 61.5° E
7.5	0.80	S 63.0° E

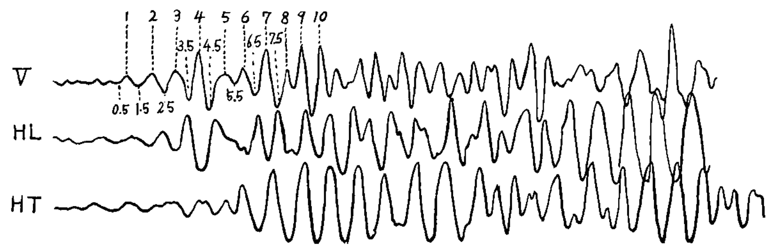

Fig. 2 An example of seismograms of volcanic explosion earthquakes. 0.5, 1.0, 1.5 and etc indicate the phase number. From above the vertical, longitudinal for the Minamidake crater and transversal components at the position 1 are traced.

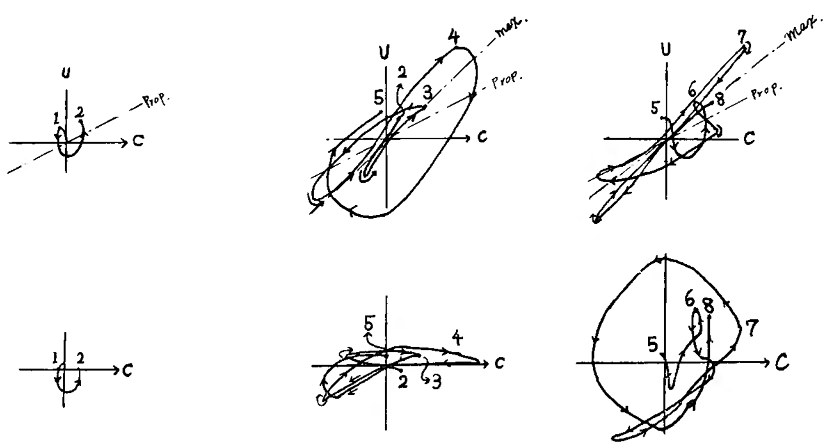

Fig. 3 An example of orbital motions corresponding to the seismograph shown in Fig. 2. *U* and *C* indicate upwards direction and direction to crater, respectively. The upper figures show vertical plane and the lower horizontal plane. Max. indicates the maximum gradient of the ground surface of the position 1. Prop. indicates the gradient of the ground surface along the line from the position 1 to crater

3～5.5 is polarized in the vertical plane and exhibits retrograde elliptic motion, one axis of which is situated in the ground surface. From these facts it is suggested that the third wave group consists of a surface wave of Rayleigh type. The fourth wave group corresponding to the phases 6～8 is polarized in the ground surface and exhibits an elliptic motion. Thus the fourth wave group is thought a surface wave of Love type.

3. Location of source of explosive earthquakes

It must be noted that a certain deviation of propagation directions between the first and the other groups is not always due to any error in measurement, but partly due to the followings: the plane of tripartite site used is not paralled with the horizon, that is, the position 3 is situated at about 50 m lower than the hight of the position 2. If we consider that the source is not on surface and the first group is of bodily wave and the others are of surface wave, it is natural that the apparent direction of travelling of bodily wave deviates from that of surface wave. The bodily wave appears to be travelling from somewhat northwards and on the other hand the surface wave is not suffered. If the source of earthquake is situated at any depth beneath the northen edge of the Minamidake crater. from which the surface wave groups appear to travel, the deviation of apparent travelling directions between bodily and surface waves may be explainable by the supposition that the source is situated at the depth of about 1.0 km beneath the top of the Minamidake. In this case, of course, the phase velocities of bodily waves must be faster than the apparent velocities as previously described, probably over about 2.0 km/s. Such a deviation of direction of travelling is clearly found in the other records obtained by us. Thus if a tripartite system is set as being inclined to the horizon, for example on a hillside, to determine both directions of travelling of bodily and surface waves enable us to find the depth of source, though not accurately.

4. Some nature of explosive earthquake

The first wave group is probably identified with compressional waves, and its phase velocity is about 2.0 km/s. The second wave group is not yet identified with any clear waves, but may be a kind of surface waves, as a higher mode of Rayleigh type, since the propagation direction belongs to those of surface waves and moreover its phase velocity is compatible with those of surface waves. At any rate, any clear SH-wave is not found. Conversely, there exist a surface wave of Love type, and moreover its amplitude is compatible with that of Rayleigh type. The further studies on this interesting nature of explosion earthquake will be published in future.

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